The usefulness of the modified extra-oral vacuum aspirator (EOVA) from household vacuum cleaner in reducing bacteria in dental aerosols

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Abstract

Aerosol containing patients' blood and drill dust from dental plaque microorganisms, tooth substances and filling materials can cause environmental pollution in the dental clinic. Currently, as a preventive measure against air pollution caused by the dental procedures, dust-collecting aspirators such as an extra-oral vacuum aspirator (EOVA) are coming into general use. In this experiment, we tested the eliminating effects of modified EOVA from the household vacuum machine with the *E.coli* solution aerosol in a manikin and the aerosol from actual dental treatment procedures, scaling and drilling a tooth, in human subjects. The results demonstrated that this inexpensive modified machine is highly effective.

Introduction

Hospital infection has been a great concern, not only for workers in the clinical office and hospital, but also for patients. In dental clinics, there are generally many risks of infection with various microorganisms such as bacteria and viruses (1-3). Aerosols containing blood, saliva and drill dust from patients, especially in treatments using high-speed air turbines, comprise a significant source of pollution (4). Ultrasonic scalers and drill dust from prostheses also spread infections (5). Recently, the use of a powerful vacuum aspirator set close to the patient's mouth has been proven quite effective in preventing pollution caused by dispersed contaminants in the dental clinic.

For these reasons, the extra-oral vacuum aspirator (EOVA) has been recommended in order to protect those involved in dental treatment from contaminated aerosol sprayed on their faces (6). Unfortunately, the available commercial vacuum aspirators are very expensive and can be used with the certain type of dental units. Therefore, they are not common use in most dental clinics. To reduce the cost of this machine, the engineering unit in the Faculty of Dentistry, Prince of Songkla University, Thailand, has worked for months to modify a much cheaper house-hold vacuum cleaner to become a dental clinic's EOVA. The purpose of this study was to examine the effectiveness of this modified extra-oral vacuum aspirator in eliminating the bacteria presented during dental works.

Materials and Methods

EOVA device

The 1100 Watts wet-dry-blow vacuum cleaner machine produces maximum negative pressure at 70 mm. Hg was used in this experiment (Fig. 1a). It was modified by removing the dust bag and plugging the air outlet with a tube connected to the dental unit's drainage system (Fig. 2, ii). The vacuum's soft hose was replaced by a 2 meter's long soft hose with 4 cm. in diameter whose another end was connected to the cone-shaped white plastic cup (Fig. 2, i). The hose was tightly connected with adjustable stalk that can stabilize the cup in the desired position and direction. The vacuum cleaner was put inside the mobile cupboard (Fig. 1b). The power switch was removed to the outside to give easier access. Spatter and aerosol contamination was evacuated through the cone-shaped plastic cup and then was drained via the dental unit's wasted water drainage system. The excess contaminated water was kept inside the vacuum's tank and was treated with disinfectant to eliminate the microorganisms (Fig. 2, iii).

Examination of the efficiency of EOVA

In order to examine the efficiency of EOVA in eliminating bacteria, the experiment was designed into two phases. As an initial experiment, simulated dental procedures were performed on the teeth in a manikin. We used a manikin because we used a bacterial strain, *Escherichia coli* (*E.coli*), as an indicator of dissemination. The manikin head was set up in a dental chair to simulate dental restorative procedures. A culture solution of *Escherichia coli* (*E.coli*, 1.0-1.2 × 10^5 CFU/ml) was contained in the air turbine's water tank of the dental unit. Then *E.coli* were scattered when the 1st molar tooth of manikin was drilled. The drilling condition was 120 s while EOVA device was being run at the same time. A McConkey agar culture plate, a selective medium for *E.coli*, was placed on the chest of manikin to collect the *E.coli* aerosol. The control was done the same as described without running of EOVA device.

In the second phase of the study, we investigated spatter of oral bacteria during actual dental treatment procedures in human subjects. Twenty-four separate procedures were performed on different days. Fourteen procedures involved restorative preparation on teeth in different area of the mouth. A high-speed handpiece with water spray and high-volume evacuation was used. In the other ten procedures, scaling was performed with an ultrasonic scaler. Blood agar culture plates, enriched media for all bacteria, were placed on the chest of subjects as we performed in manikin. The plates were exposed 120 s during each cavity preparation and scaling procedure that involved using a high-speed handpiece with water spray or an ultrasonic scaler. The control was done the same as described without running of EOVA device. The plates were incubated for 24 h at 37°C, and bacterial colonies counted. The contaminated water in vacuum's tank was sampled before and after treated with disinfectant to check for the bacteria. To control for the background bacterial contamination in the air, level were determined before each experiment or treatment procedure, by exposing culture plates to the air for 120 s.

Results

Two phases of the experiments were conducted. In the first experiment, a culture solution of *E. coli* was released as an aerosol and sucked into the intake of the vacuum aspiration. The amount of *E.coli* was kept at the same level at $1.0 - 1.2 \times 10^5$ CFU/ml. The total 38 experiments were conducted separately. The result showed there was the statistically significant elimination of the *E.coli* solution aerosol by the EOVA ($P = 0.01$, t-test). The mean recoverable counts of *E.coli* without using EOVA were 29.26 ± 19.13 CFU/ml and were 17.26 ± 12.56 CFU/ml when using EOVA. In the second experiment, the spatter of oral bacteria was examined during actual dental treatment procedures, restorative preparation and scaling, in human subjects. Generally, The mean recoverable counts of oral bacteria were significant low when using EOVA. The details were shown in Table 1 and Table 2. There was a recovery of bacteria in the water in vacuum's tank; however, they were disappeared after treated the water with disinfectant. The control plates showed only a small numbers of environmental bacteria.

Discussion

Bacteria in the mouth and respiratory tract are dislodges during dental procedures and become aerosol contaminants that may cause infections such as pulmonary TB (7,8), pneumonia and influenza. In addition, Blood is the most important sources of HIV and HBV and other blood-borne pathogens, so that blood, saliva and gingival fluid from all dental patients must be considered infective (9,10). It has been stated that infectious aerosol increases when the drilling of human teeth to the size of about 0.5-5.0 μm, which is microbiologically and hygienically hazardous and can be inhaled with little difficulty. Thus, the possibility of infectious aerosol being inhaled by humans is increased. In spite of rigorous barrier techniques, dental personnel may be exposed to significant spatter and aerosol dissemination. Carolyn and Nancy (2) demonstrated that contaminated aerosol can penetrated the single layered face masks behind the face masks shields to enter the nose. The face-shields were substantially inferior to masks on preventing penetration of airborne debris, because of their lack of peripheral fit. Therefore, the EOVA was originally designed to remove dust and water drops can scatter upon the face of dentist using an air turbine with water. The main purpose is to protect dentists from the infectious aerosol.

Our study provides the evidence that the modified EOVA from the household cleaner machine is sufficient to reduce the spatter and aerosol dissemination. For some years, EOVA is market commercially by various companies. Each machine can specifically be used with the recommended model; in fact, it can be fit with the same-brand-named dental unit. Moreover, it costs very expensive, especially for a developing country with economic problem. The modified EOVA used in this experiment is cheap, movable, easy to set up and can be modified to be used with any dental unit available.

Conclusion

The main advantages of the modified EOVA machine are: (i) it is highly effective to prevent the air pollution from a patient's mouth at treatment (ii) it can be modified to use with any dental unit, and (iii) it is relatively inexpensive.

Acknowledgements

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Legend of Figures

Fig. 1a Showing the wet-dry-blow household vacuum cleaner machine before modified.

Fig. 1b The vacuum machine after modified to be an extra-oral vacuum aspirator and fit to a dental unit.

Fig. 2 Diagram showing the contaminated aerosol was aspirated through the plastic cup (i). The water spray dropped down to the bottom of the tank (iii) while the contaminated aerosol was drawn into the dental unit's drainage system via a tube (ii).

Table 1. The number of oral bacteria counts recovered during scaling treatment

Patient	Bacterial count (colony) of scaling treatment for 120 sec at the different quardant											
	Lower right		Lower left		Upper right		Upper left		Upper anterior		Lower anterior	
	Without EOVA	With EOVA	Without EOVA	With EOVA	Without EOVA	With EOVA	Without EOVA	With EOVA	Without EOVA	With EOVA	Without EOVA	With EOVA
1	45	41	16	6	87	17	136	49	23	13	48	45
2	4	4	4	1	14	7	0	0	86	11	4	3
3	0	0	7	4	21	10	42	40	16	6	0	0
4	1	0	351	31	8	2	8	5	60	40	1	0
5	6	2	0	1	3	1	13	10	42	22	6	2
6	0	2	1	2	6	0	67	9	2	0	0	2
7	3	1	11	6	12	6	1	2	17	17	3	1
8	21	7	360	280	46	11	71	22	29	23	21	6
9	9	3	128	78	10	3	97	32	260	74	9	2
10	27	4	32	3	7	2	74	43	45	17	24	4
Z	- 2.176		- 2.501		- 2.812		- 2.549		- 2.670		- 2.176	
Asymp. Sig.*	.030		.012		.005		.011		.008		.030	

* Wilcoxon Singed Ranks test

Table 2. The number of oral bacteria counts recovered during the restorative preparation

Tooth #	Bacterial count (colony)	
	Without EOVA	With EOVA
27	18	7
23	800	159
37	24	2
27	4	2
47	4	2
47	4	2
37	22	5
47	6	0
11	38	19
11	334	204
36	37	0
11	272	57
17	23	1
22	102	9
Z	- 3.300	
Asymp. Sig.*	.001	

* Wilcoxon Singed Ranks test

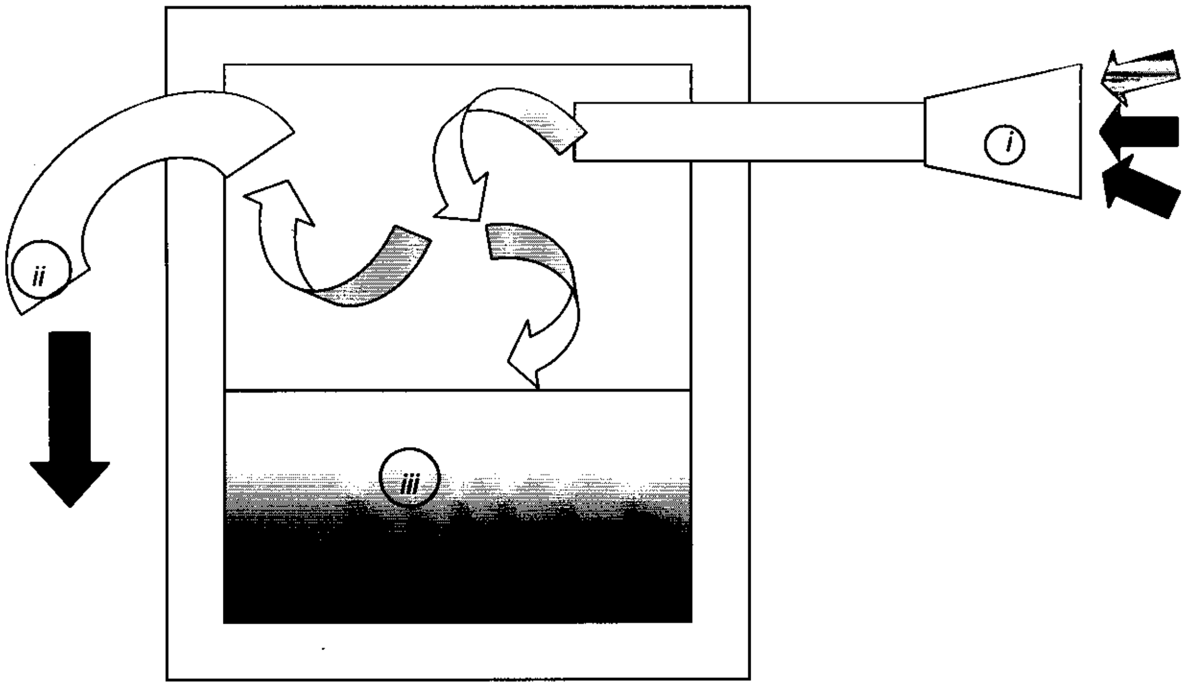

Fig. 2

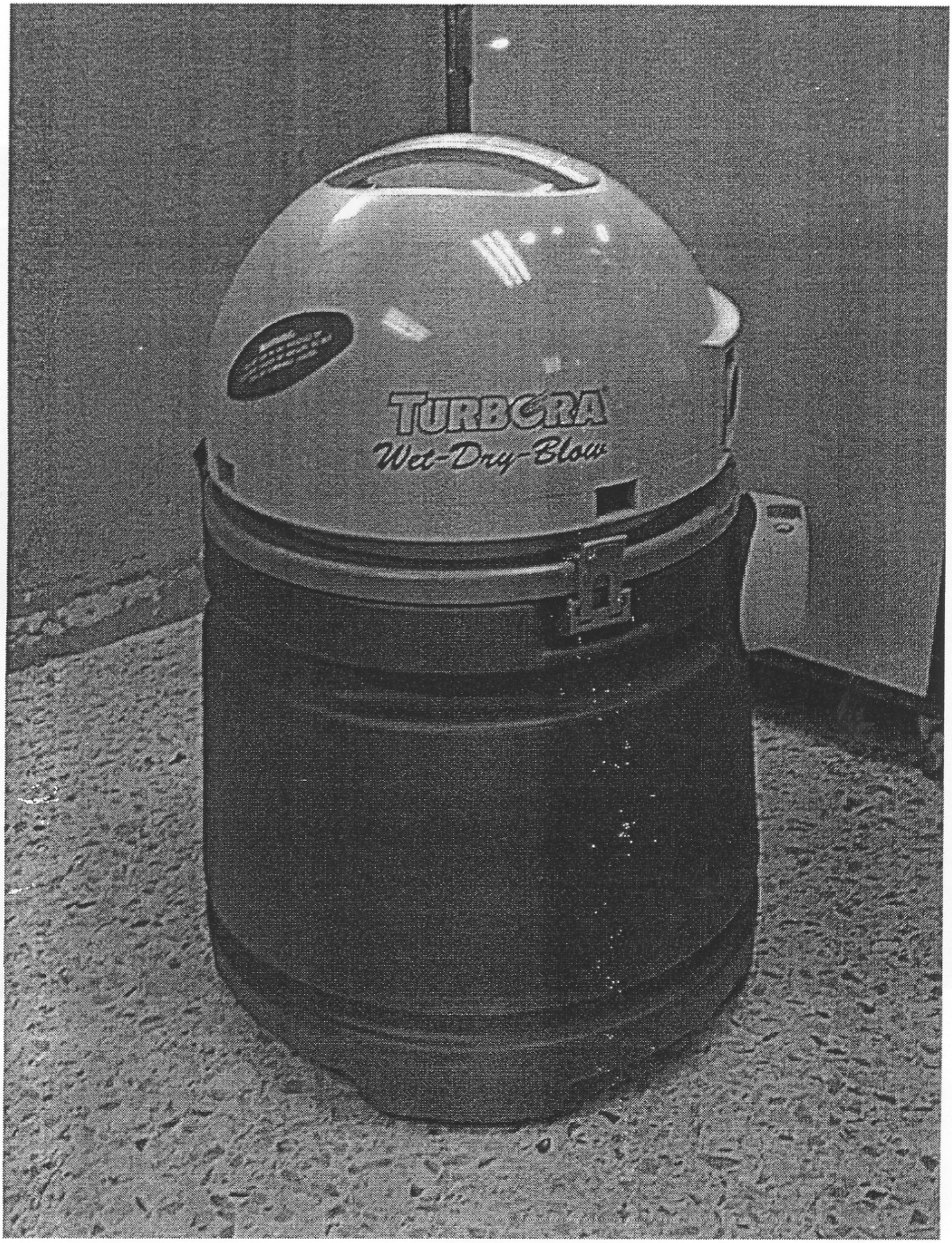

Fig. 1

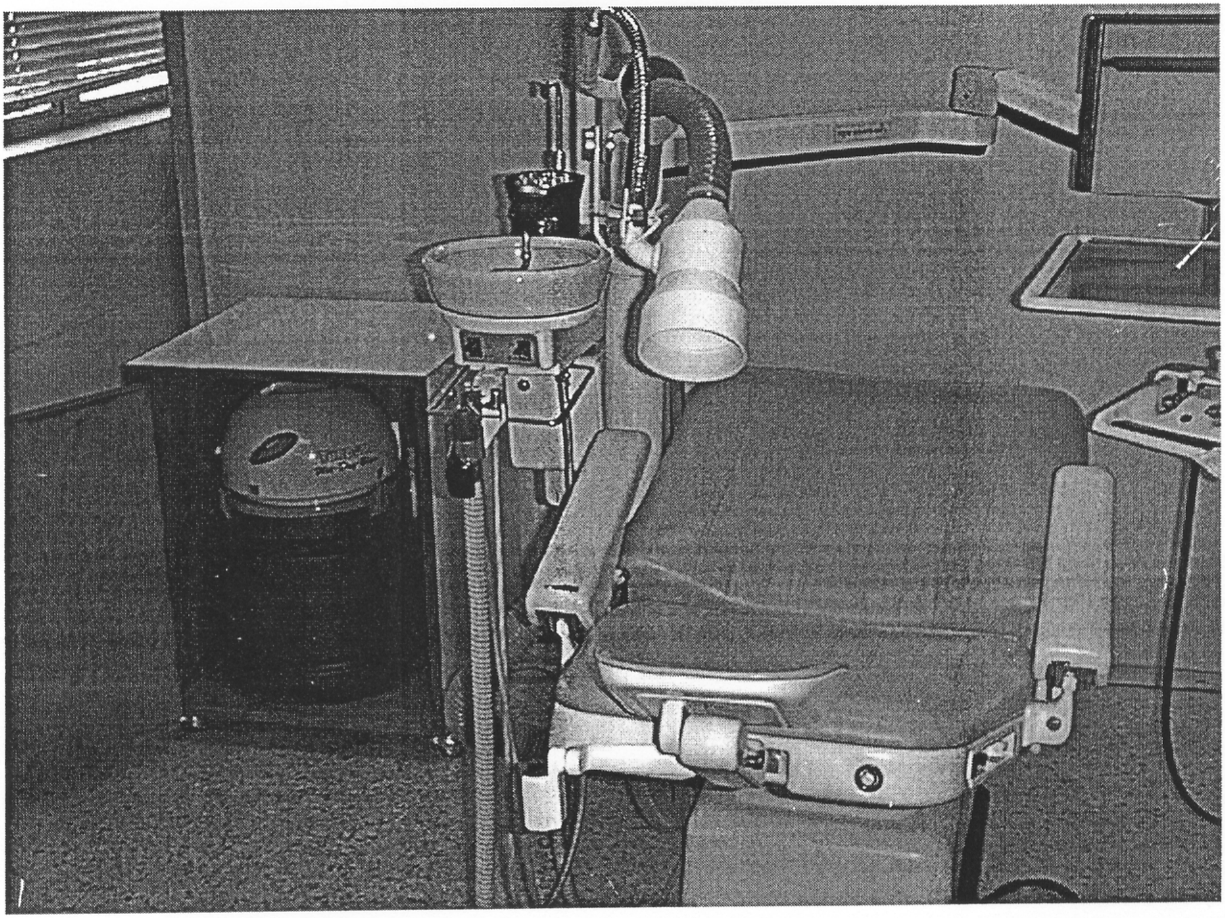

Fig. 2